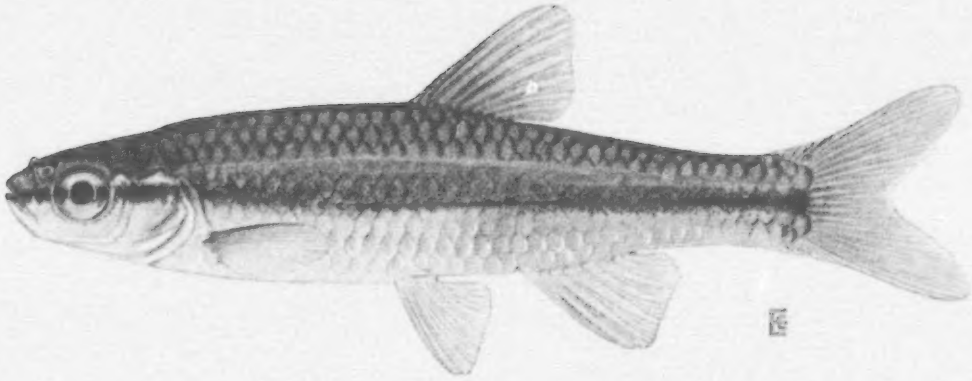
COSEWIC
Assessment and Status Report

on the

Pugnose Shiner
Notropis anogenus

in Canada



THREATENED
2013

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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Previous report(s):

COSEWIC. 2002. COSEWIC assessment and update status report on the Pugnose Shiner *Notropis anogenus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 15 pp.

Holm, E. and N.E. Mandrak. 2002. Update COSEWIC status report on the Pugnose Shiner *Notropis anogenus* in Canada, *in* COSEWIC assessment and update status report on the Pugnose Shiner *Notropis anogenus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-15 pp.

Parker, B., P. McKee and R.R. Campbell. 1985. COSEWIC status report on the Pugnose Shiner *Notropis anogenus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 14 pp.

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COSEWIC
Assessment Summary

Assessment Summary – May 2013

Common name
Pugnose Shiner

Scientific name
Notropis anogenus

Status
Threatened

Reason for designation
The species has a small area of occupancy and consists of numerous small populations, many of which may not be viable. At least two populations have been extirpated. Habitat degradation and loss continues to threaten populations, particularly in the western part of their distribution in the Lake Huron, Lake St. Clair and Lake Erie watersheds.

Occurrence
Ontario

Status history
Designated Special Concern in April 1985. Status re-examined and designated Endangered in November 2002. Status re-examined and designated Threatened in May 2013.

COSEWIC
Executive Summary

Pugnose Shiner
Notropis anogenus

Wildlife Species Description and Significance

The Pugnose Shiner, *Notropis anogenus*, is a small, slender fish that reaches a maximum total length (TL) of 72 mm. There is a dark lateral stripe that extends onto the snout, eight dorsal rays, and a very small and upturned mouth. These characters distinguish it from all other species in the family Cyprinidae in Canada. A wedge-shaped spot is usually present on the caudal peduncle.

Distribution

The Pugnose Shiner is found in central North America where it occurs in the upper Mississippi River and Great Lakes basins, and the Red River drainage of Minnesota and North Dakota. In Canada, the Pugnose Shiner has been found only in Ontario and is limited to the Old Ausable Channel and a tributary of the Saugeen River in the Lake Huron basin; Walpole Island, Mitchell's Bay, St. Clair National Wildlife Area, and four tributaries in the Lake St. Clair basin; Detroit River, Canard River and Long Point Bay in the Lake Erie basin; Trent River, Wellers Bay, West Lake, East Lake, Black River, and Waupoos Bay in the eastern Lake Ontario basin; and the St. Lawrence River between Eastview and Lancaster. Historically, the Pugnose Shiner occurred in Point Pelee National Park and Rondeau Bay in the Lake Erie basin.

Habitat

The Pugnose Shiner is typically found in clear, quiet areas of lakes, stagnant channels, and large rivers. This species is almost always found in association with submergent and emergent aquatic vegetation over substrates containing muck, sand, marl and, occasionally, silt and clay, in water depths of up to 2.3 m.

Biology

Little is known of the life history of Pugnose Shiner. Its small size, elusive nature and preference for areas with dense vegetation make it difficult to sample. It is known to spawn in densely vegetated, shallow water up to 2 m deep with a sand, silt, and gravel substrate. The Pugnose Shiner does not guard its young. In Wisconsin, spawning has not been observed; however, gravid females were observed from mid-May into July at temperatures of 21-29°C. In Ontario, a population of Pugnose Shiner caught in June was likely spawning because some females appeared to be partially spent. Mature females were 41-56 mm TL, and mature males were 30-38 mm TL. Because of its small size, the Pugnose Shiner likely limits its movement to small distances. This species swims in small schools that immediately disperse into vegetation when threatened. The Pugnose Shiner feeds on plants, algae, small leeches, cladocerans, and trichopterans. In laboratory experiments, Pugnose Shiner has been shown to have reduced schooling and swimming abilities in increased turbidity.

Population Sizes and Trends

Population sizes of Pugnose Shiner are not known for Canada. In 2010, Fisheries and Oceans Canada (DFO) and Ontario Ministry of Natural Resources (OMNR) attempted to estimate population sizes using depletion sampling of eight Pugnose Shiner populations. Data were sufficient to estimate the mean density of individuals in suitable habitat in four populations; it ranged from 0.051 individuals/m^2 to 0.156 individuals/m^2. Additional study is required to measure the total amount of suitable habitat in order to determine population size. The lack of historical sampling at many sites with recent records makes it difficult to evaluate trends in distribution.

Threats and Limiting Factors

Degradation and loss of preferred habitat, including removal and control of aquatic vegetation, habitat modification, and sediment and nutrient loading, are the greatest threats to the Pugnose Shiner. Loss of habitat from shore development and destruction of native littoral-zone macrophyte communities probably caused the extirpation of the Pugnose Shiner from two lakes in southern Wisconsin. Exotic species, including both fishes and aquatic plants may also negatively impact the Pugnose Shiner. The introduction of whole-lake treatment herbicides in the United States has also likely impacted the Pugnose Shiner. Climate change may have direct and indirect effects because of the specific habitat vulnerabilities of this species.

Protection, Status, and Ranks

The Pugnose Shiner is listed as Endangered under Schedule 1 of the federal *Species at Risk Act*, and as Endangered under the Ontario *Endangered Species Act*, 2007. The species is listed as vulnerable both globally (G3) and in the United States (N3). In Canada, it is ranked as imperilled (N2). Provincially, it is ranked as imperilled (S2) in Ontario.

TECHNICAL SUMMARY

Notropis anogenus
Pugnose Shiner Méné camus
Range of occurrence in Canada (province/territory/ocean): Ontario

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines(2008) is being used)	2 yrs
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Unknown
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	Unknown
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and Occupancy Information

Estimated extent of occurrence 91,000 km² (2002-2011) 39,000 km² (<2002)	91,000 km²
Index of area of occupancy (IAO) (see Figure 9) 308 km² (2002-2011) 88 km² (<2002)	308 km²
Is the total population severely fragmented?	Comes close to meeting the definition of severely fragmented
Number of locations* (+ - extirpated; # - new since 2002) #Teeswater River Old Ausable Channel #Mouth Lake Lake St. Clair, Chenal Escarte #Whitebread Drain/Grape Run #Maxwell Creek #Little Bear Creek #Macleod Creek Detroit River +Point Pelee +Rondeau Bay	16

* See Definitions and Abbreviations on COSEWIC website and IUCN 2010 for more information on this term.

Long Point Bay #Trent River #Wellers Bay #West Lake #East Lake #Black River, Waupoos Bay + Gananoque River St. Lawrence River	
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] continuing decline in number of populations?	No
Is there an [observed, inferred, or projected] continuing decline in number of locations*?	No
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat?	Yes
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations*?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	N Mature Individuals
	Unknown
Total	

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Unknown

Threats (actual or imminent, to populations or habitats)

Degradation and loss of preferred habitat; exotic species; climate change.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? Michigan (S1); New York (S3); Ohio (Extirpated)	
Is immigration known or possible?	Possible
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

* See Definitions and Abbreviations on COSEWIC website and IUCN 2010 for more information on this term.

Status History

COSEWIC: Designated Special Concern in April 1985. Status re-examined and designated Endangered in November 2002. Status re-examined and designated Threatened in May 2013.

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Threatened	Does not meet any criteria, but designated Threatened because of a small area of occupancy, declining habitat quality, and concerns that many subpopulations may not be viable.
Reasons for designation: The species has a small area of occupancy and consists of numerous small populations, many of which may not be viable. At least two populations have been extirpated. Habitat degradation and loss continues to threaten populations, particularly in the western part of their distribution in the Lake Huron, Lake St. Clair and Lake Erie watersheds.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): There is no information available on the number of individuals.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. Nearly meets Endangered for B2ab(iii) since the IAO <500 km², comes close to meeting the definition of severely fragmented, and continuing declines in habitat quality.
Criterion C (Small and Declining Number of Mature Individuals): There is no information available on the number of individuals.
Criterion D (Very Small or Restricted Total Population): There is no information available on the number of individuals.
Criterion E (Quantitative Analysis): Quantitative analyses have not been completed.

PREFACE

The Pugnose Shiner remains a relatively poorly studied and monitored species – very little has been published on its biology since the last COSEWIC report. All sites where it had been found in southern Ontario, and many adjacent sites, have been sampled since the last report and it is still present at most historical sites, except for Point Pelee and Rondeau Bay in Lake Erie. Since the last report, it has been found at many additional sites in the Lake Huron drainage (Teeswater River, Mouth Lake), eastern Lake Ontario drainage (Trent River, Wellers Bay, West Lake, East Lake, Black River, and Waupoos Bay), and St. Lawrence River. These findings are likely the result of increased sampling using appropriate gear and likely represent an expansion of our knowledge of the distribution of the species, rather than recent expansion by the species itself. Extent of occurrence has increased by 2.3-fold and area of occupancy has increased by 3.50-fold. Insufficient sampling has occurred to determine trends in abundance. Threats to Pugnose Shiner are believed to be degradation of habitat and water quality, exotic species, and climate change – all ongoing threats within their distribution in Canada.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2013)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment Canada / Environnement Canada
Canadian Wildlife Service / Service canadien de la faune
Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

on the

Pugnose Shiner
Notropis anogenus

in Canada

2013

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Table 2. Cytochrome b haplotypes (corresponding to Figure 4) and locations where they were found across the range of the Pugnose Shiner. Population abbreviations as in Table 1. McCusker *et al.* (draft). 8

Table 3. Threat Status for all Pugnose Shiner populations in Canada, resulting from an analysis of both the threat likelihood and threat impact. The number in brackets refers to the level of certainty assigned to each threat status, which is reflective of the lowest level of certainty associated with either initial parameter (threat likelihood, or threat impact). Clear cells do not necessarily represent a lack of a relationship between a population and a threat; rather, they indicate that either the threat likelihood or threat impact was unknown. From Bouvier *et al.* (2010)..... 19

WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Class	Actinopterygii
Order	Cypriniformes
Family	Cyprinidae
Species	*Notropis anogenus,* Forbes 1885: 138
	Hybopsis anogenus, Jordan, Evermann, and Clark 1930: 136
Common Name	Pugnose Shiner; méné camus

The Pugnose Shiner, *Notropis anogenus* Forbes 1885 (Figure 1) is one of 91 species in the genus *Notropis* of the carp and minnow family Cyprinidae (Page and Burr 2011). Historically, the Pugnose Shiner was thought to be the closest relative of the Topeka Shiner (*N. topeka)* because it, "shares many structural characters and bears strong resemblance" (Bailey 1959). However, more recent phylogenetic analyses conducted on *Notropis* and *Hybopsis* indicated that the Pugnose Shiner is most closely related to the group consisting of Bigeye Shiner (*N. boops*), Blackchin Shiner (*N. heterodon*), Mimic Shiner (*N. volucellus*), and Weed Shiner (*N. texanus*) (Schonhuth and Doadrio 2003). This group, or clade, was also recognized by Mayden (1991).

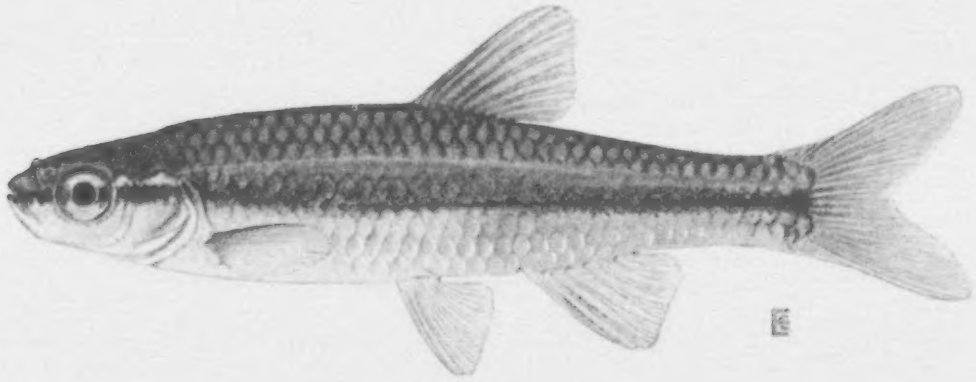


Figure 1. The Pugnose Shiner, *Notropis anogenus.* Copyright Ellen Edmonson/SAREP. Reproduced with permission from Bureau of Fisheries, New York State Department of Environmental Conservation.

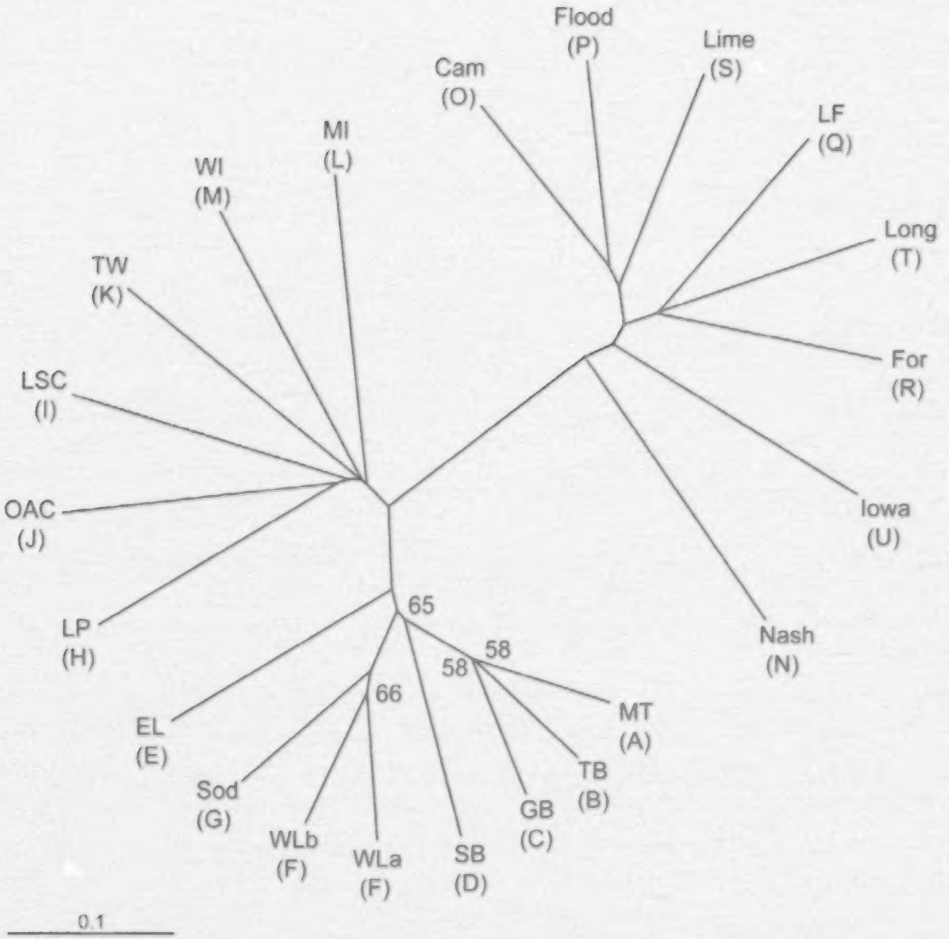
Morphological Description

The Pugnose Shiner is a small, slender fish with a dark lateral stripe that extends onto the snout (Figure 1) (Holm *et al.* 2010; Page and Burr 2011). Its mouth is very small and upturned, extending backward to below the front part of the nostril (Holm *et al.* 2010). There is usually a pale stripe on top of the dark stripe (Holm *et al.* 2010). The chin is dark. The back has yellow tints and the sides are silvery (Holm *et al.* 2010). There is often a wedge-shaped spot on the caudal peduncle. Scales on the back are darkly outlined. All fins are transparent and, unlike most shiners, the peritoneum is black (Page and Burr 2011). There are eight dorsal fin rays. The largest recorded Canadian specimen is 72 mm total length (TL) (ROM 79046), with an average TL of 38-51 mm (Scott and Crossman 1973; Becker 1983). There are four species known as blackline shiners as they all have a dark line running horizontally down the side of the body. These include the Blackchin Shiner, Blacknose Shiner (*N. heterolepis*), Bridle Shiner (*N. bifrenatus*), and Pugnose Shiner. These species have overlapping distributions that may cause confusion in identification (Bouvier *et al.* 2010). The Pugnose Shiner can be distinguished from other blackline shiners by its very small, upturned mouth (Holm *et al.* 2010). The Pugnose Shiner may also be confused with the Pugnose Minnow (*Opsopoeodus emiliae*). The Pugnose Minnow has a small strongly upturned mouth, but unlike the Pugnose Shiner, has typically nine dorsal fin rays, dark areas on the dorsal fin, cross-hatched areas on the upper side, and a silvery-white peritoneum (Scott and Crossman 1973; Page and Burr 2011).

The original description of the Pugnose Shiner was based on a collection of 24 specimens from the Fox River, Illinois (Bailey 1959). Of the eight remaining type specimens in the collection of the Illinois Natural History Museum, six are Pugnose Shiner and two are Blackchin Shiner, exemplifying the similarity between these species (Scott and Crossman 1973).

Population Spatial Structure and Variability

McCusker *et al.* (draft) assessed genetic variation in the Pugnose Shiner from across its range with microsatellite loci to determine the population structure of Canadian populations and to evaluate population structure and effective population size (N_e). Populations across the North American distribution exhibited two main groups – one in the Upper Mississippi basin and one in the Great Lakes basin (Figure 2). All populations were significantly different with the exception of those at three sites on the St. Lawrence River less than 10 km apart (Goose Bay, Mallorytown Landing, Thompson's Bay; Tables 1, 2; Figures 3, 4). Effective population size evaluated with linkage disequilibrium indicated potential concern for Teeswater River population (N_e<50 individuals) (Table 1), although further sampling would help clarify this. Phylogeographic analysis supported the previously held hypothesis that the Pugnose Shiner survived in a single Mississippian refugium. Note that the recently discovered population in the Trent River has not yet been included in this analysis.



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Pop code	Location	Abb.	Year collected	Drainage basin	State/ Prov.	n-micros	Ave H_e	Ave N_A	Ave A_R	n-mtDNA	H	π
A	Mallorytown Landing	MT	2009	St. Lawrence	Ont	42	0.42	5.3	2.33			
B	Thompson's Bay	TB	2009	St. Lawrence	Ont	55	0.41	8.0	2.35	10	0.38	0.025
C	Goose Bay	GB	2009	St. Lawrence	NY	43	0.42	5.9	2.33			
D	Smith Bay	SB	2010	Lake Ontario	Ont	50	0.36	3.7	2.01			
E	East Lake	EL	2010	Lake Ontario	Ont	48	0.37	5.1	2.20			
F1	West Lake	WL-a	2009	Lake Ontario	Ont	32	0.47	5.4	2.48			

Pop code	Location	Abb.	Year collected	Drainage basin	State/ Prov.	n-micros	Ave H_o	Ave N_A	Ave A_R	n-mtDNA	H	π
F2	West Lake	WL-b	2010	Lake Ontario	Ont	35	0.45	5.6	2.44			
G	Sodus Bay	Sod	2009	Lake Ontario	NY	50	0.42	5.1	2.31	8	0.54	0.022
H	Long Point Bay	LP	2009	Lake Erie	Ont	24	0.47	5.4	2.55	6	0.33	0.028
I	Lake St. Clair	LSC	19962007	Lake St. Clair	Ont	11	0.56	4.0	2.72	7	0.86	0.083
J	Old Ausable Channel	OAC	2005-9	Lake Huron	Ont	51	0.48	5.3	2.49			
K	Teeswater	TW	2010	Lake Huron	Ont	24	0.24	2.7	1.78	8	0.43	0.018
L	Black River	MI	2010	Lake Superior	Mich	57	0.39	5.7	2.18	7	0.71	0.067
M	Cross Lake	WI	2009	Mississippi River	Wis	32	0.52	5.9	2.56	11	0.18	0.008
N	Nashwauk Lake	Nash	2009	Upper Mississippi River	Minn	29	0.45	4.7	2.41	8	0.00	0.000
O	Cameron Lake	Cam	2009	Rainy Lake, Lake of the Woods	Minn	8	0.32	2.9	2.07			
P	Floodwood Lake	Flood	2009	Lake Superior	Minn	6	0.39	2.7	2.14			
Q	Little Floyd River	LF	2009	Red River of the North	Minn	11	0.44	4.9	2.59	8	0.46	0.021
R	Forest Lake	For	2009	St. Croix River, L. Mississippi R.	Minn	22	0.32	4.4	2.07	8	0.71	0.060
S	Limestone Lake	Lime	2009	Upper Mississippi River	Minn	8	0.42	4.4	2.54			
T	Long Lake	Long	2009	Crow River, Upper Mississippi R.	Minn	6	0.56	4.9	3.10			
U	West Okoboji Lake	Iowa	2010	Des Moines River	Iowa	4	0.54	3.0	2.72	4	0.83	0.042
	Total					648				85		

Table 2. Cytochrome b haplotypes (corresponding to Figure 4) and locations where they were found across the range of the Pugnose Shiner. Population abbreviations as in Table 1. McCusker *et al.* (draft).

Haplotype:	TB	Sod	LP	LSC	Tees	MI	Cross	For	LF	Nash	Iowa
N	10	8	6	7	8	7	11	8	8	8	4
Hap_1	8				6		1		6	8	1
Hap_2	1										
Hap_3	1										
Hap_4		5									
Hap_5		3									
Hap_6			1								
Hap_7			5	1							
Hap_8				1							
Hap_9				3							
Hap_1				1							

Haplotype:	TB	Sod	LP	LSC	Tees	MI	Cross	For	LF	Nash	Iowa
N	10	8	6	7	8	7	11	8	8	8	4
Hap_11				1							
Hap_24					2						
Hap_2						4					
Hap_21						1					
Hap_22						1					
Hap_23						1					
Hap_12							1				
Hap_13								4			
Hap_14								2			
Hap_15								2			
Hap_16									1		
Hap_17									1		
Hap_18											2
Hap_19											1

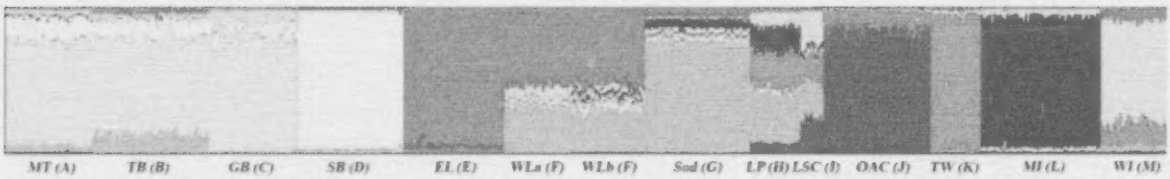

Figure 3. Clustering analysis from STRUCTURE based on 6 loci, k=8, with sample location as the prior. Each individual is assigned a probability of belonging to each of the k=8. Population abbreviations and codes in Table 1. McCusker *et al.* (draft).

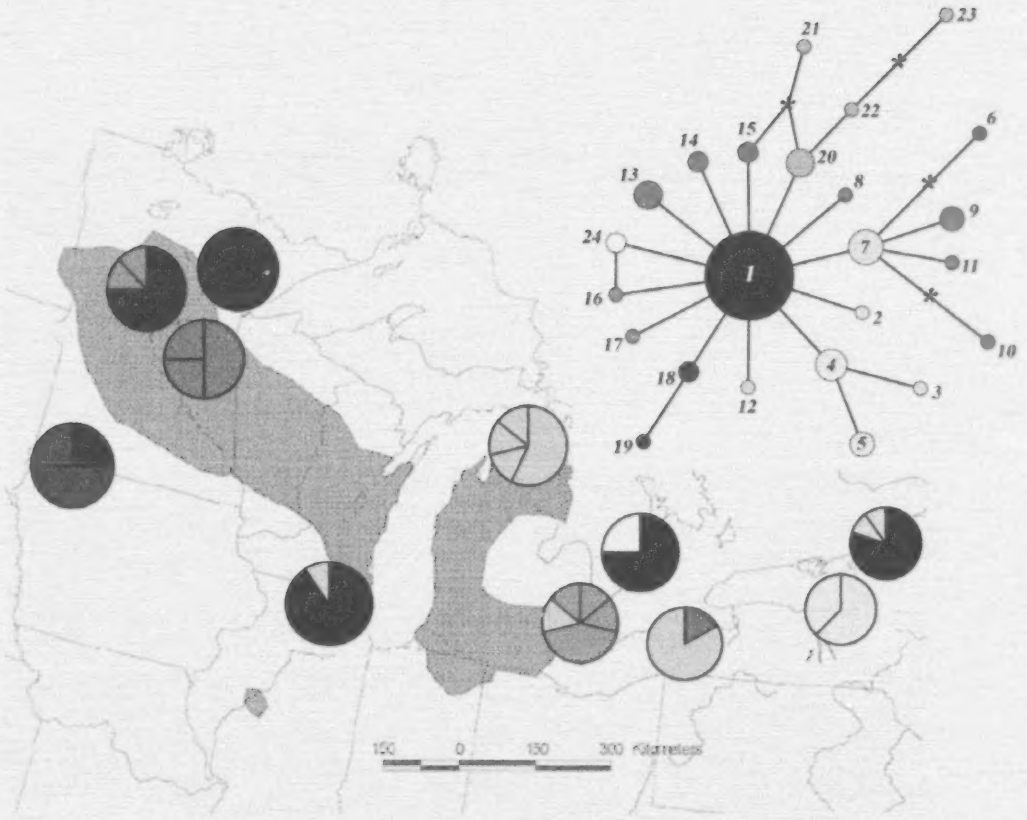

Figure 4. A statistical parsimony network of haplotypes for Pugnose Shiner (top right) for which the size of each circle indicates its frequency and the lines represent mutational steps. 'Missing' haplotypes are indicated by asterisks. Haplotypes found predominantly in eastern drainages are mainly displayed on the right of the network; those found in western populations are on the left. The distribution of haplotypes across the range are indicated with pie diagrams. McCusker *et al.* (draft).

Designatable Units

All of the Canadian populations were found in only one of the two genetic groups (Figure 2), and all populations occur in a single COSEWIC National Freshwater Biogeographic Zone, the Great Lakes-Upper St. Lawrence Biogeographic Zone; therefore, the Canadian populations of Pugnose Shiner should be considered to constitute a single designatable unit.

Special Significance

The strict habitat requirements of the Pugnose Shiner make it a good indicator of environmental quality (Smith 1985) as it is intolerant to habitat degradation such as increased turbidity (Barbour *et al.* 1999). Pugnose Shiner in Canada is at the northern extreme of its range; however, climate change may potentially allow it to spread into watersheds in southern Quebec and central Ontario (Chu *et al.* 2005). The spread into Ontario would mimic the pattern of invasion many species have taken from the Mississippian refugium (Mandrak and Crossman 1992).

DISTRIBUTION

Global Range

The Pugnose Shiner is found in central North America (Figure 5). It occurs in the upper Mississippi River and Great Lakes basins (Page and Burr 2011). In the Mississippi drainage, it is found in several tributaries of the Mississippi River in Illinois, Wisconsin, and Minnesota. It is found in the extreme upper Red River of the North drainage of Minnesota and, historically, North Dakota. In the Great Lakes drainage, it is found in the Michigan, Huron, Lake St. Clair, western Lake Erie, and eastern Lake Ontario basins, and in the upper St. Lawrence River. The Pugnose Shiner is considered rare and disappearing over most of its range (Page and Burr 2011). It is extirpated in Ohio (Trautman 1981), may be extirpated in North Dakota (NatureServe 2011) and declining in Michigan (Latta 2005).

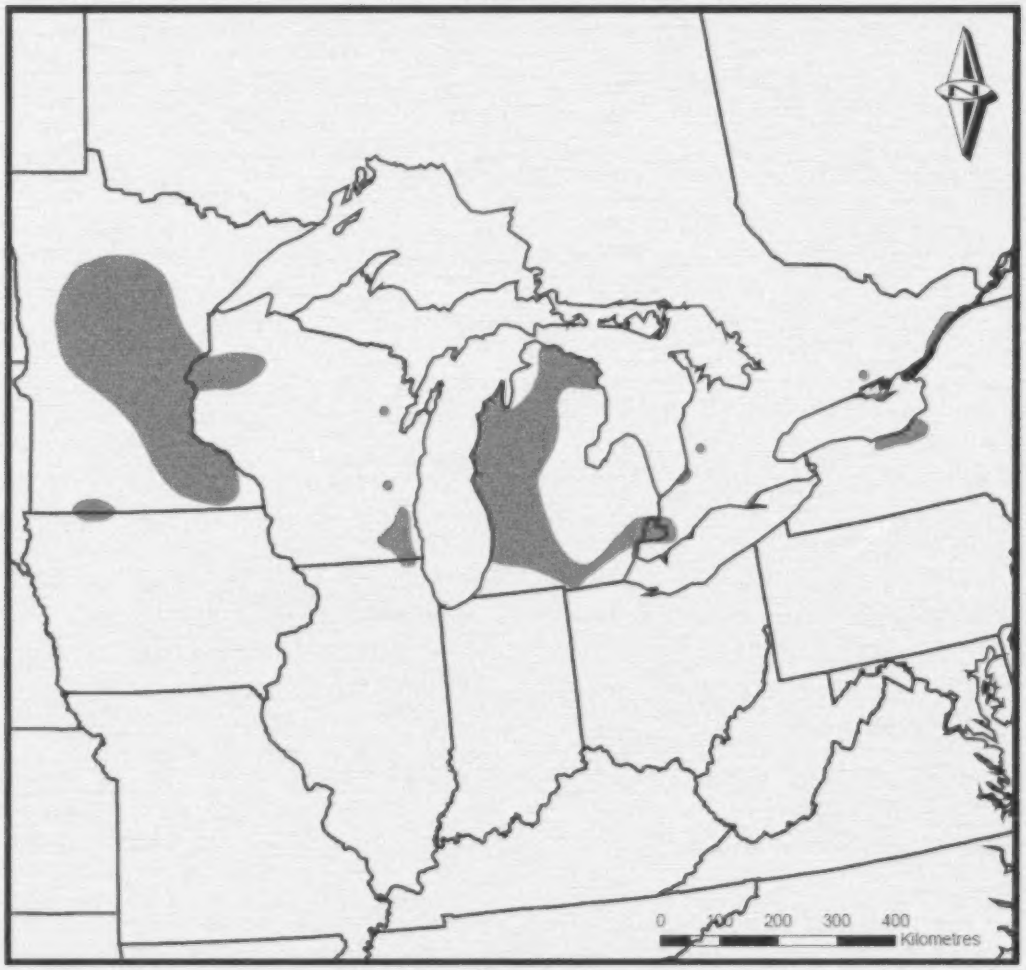

Figure 5. Current global distribution of Pugnose Shiner, *Notropis anogenus*. Modified from Page and Burr (2011) and Bailey *et al.* (2004).

Canadian Range

In Canada, the Pugnose Shiner has been found only in Ontario and is limited to six disjunct areas in the southern Lake Huron, Lake St. Clair, western and central Lake Erie drainages, and eastern Lake Ontario basin, and in the upper St. Lawrence River (Bouvier *et al.* 2010) (Figure 6). In the Lake Huron basin, it occurs in the Old Ausable Channel, Mouth Lake, and the Teeswater River, a tributary of the Saugeen River. In the Lake St. Clair basin, the Pugnose Shiner has been collected at Walpole Island, Mitchell's Bay, St. Clair National Wildlife Area, and in four tributaries. In the Lake Erie basin, it historically occurred in Point Pelee National Park and Rondeau Bay; the Pugnose Shiner may now only occur in Long Point Bay and the mouth of the Canard River, a tributary to the Detroit River. It was only recently found in the Lake Ontario basin, in the Trent River, Wellers Bay, and in the Prince Edward County waterbodies of West Lake, East Lake, Black River, and Waupoos Bay. The species is present in the St. Lawrence River from Eastview in the west downstream to Lancaster.

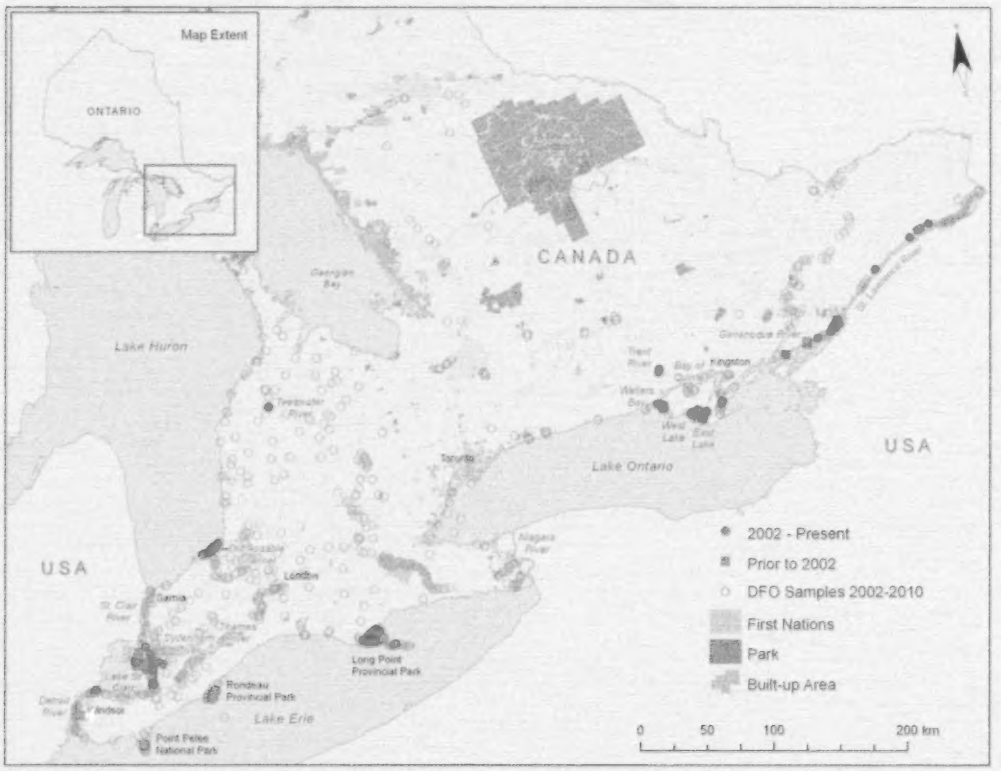

Figure 6. Canadian distribution of Pugnose Shiner, *Notropis anogenus*. DFO Samples 2002-2010 represents all fish sampling conducted by DFO during that time period.

The extent of occurrence (EO) has increased from 39,000 km^2 to 91,000 km^2, and the index of area of occupancy has increased from 88 km^2 to 308 km^2 since the last COSEWIC assessment was done in 2002. These increases are undoubtedly the result of increase in knowledge due to increased sampling of preferred habitat using appropriate gear rather than increase in actual distribution (see **Search Effort**). The most plausible serious threats, increased turbidity and loss of vegetation, are unlikely to be rapid; therefore, it is difficult to identify locations. It is clear that there are three historical sites that are no longer extant (Gananoque River, Point Pelee, Rondeau Bay). The following are widely disjunct and, therefore, distinct locations: Detroit River; Lake St. Clair; Long Point Bay; Mouth Lake; Old Ausable Channel; St. Lawrence River; Teeswater River; and Trent River. The remaining populations are close to one another, but are genetically distinct (Figure 2) and separated from one another by unsuitable, open water habitat: Black River and Waupoos Bay; East Lake; Wellers Bay; West Lake.

Search Effort

It is difficult to draw conclusions regarding the status of Canadian populations of Pugnose Shiner as many of the surveys that have detected the species were not specifically targeting it, particularly prior to 2002, and sampling gears were often different. Data on search effort, and often sampling gear, are not readily available for most historical surveys (earlier than the year 1990). Between 2002 and 2011, DFO conducted many surveys within the range of the Pugnose Shiner in Ontario using a variety of effort and gears (fine-mesh seines, boat seines, backpack electrofisher, boat electrofisher, fine-mesh trawls, fine-mesh fyke nets, minnow traps, Windermere traps) (Figure 6) (Mandrak *et al.* 2006a; Marson and Mandrak 2009; Marson *et al.* 2010; DFO, unpubl. data). In 2010 DFO conducted targeted sampling of Pugnose Shiner using fine-mesh seine nets throughout most of its Canadian range (Figure 6; N.E. Mandrak, unpubl. data). This sampling included closed area multi-pass sampling to determine population density using depletion.

In the Lake Huron basin, Pugnose Shiner was captured in the Old Ausable Channel (Ausable River watershed) in the early 1980s,1997, 2002 (45 specimens), 2004 (30), 2005 (52), 2009 (3) (DFO 2010), and 2010 (2) – only those collections since 2002 targeted the species using seines, fyke nets, and boat electrofishing (DFO, unpubl. data). In 2010, 30 Pugnose Shiner were collected for the first time in Mouth Lake, immediately south of the mouth of the Ausable River by seining (DFO, unpubl. data). A total of 28 Pugnose Shiner have been caught from the Teeswater River (Saugeen River tributary); three in 2005, one in 2009, and 24 in 2010. Two of these were captured from below a dam within the main branch of the river, a third from the tailrace, and the remaining fish from Cargill Mill Pond, a reservoir of the Teeswater River (DFO 2010). The 2009 and 2010 captures were the result of targeting the species using seines and boat electrofishing (DFO, unpubl. data). During a general survey of the fish community of the Saugeen River, undertaken by DFO in 2005 and 2006, Pugnose Shiner were not captured at sites other than Cargill Mill Pond (Marson *et al.* 2009). This survey used seines and electrofishing to collect 1,344 individuals representing 45 species from 25 sites throughout the Saugeen watershed.

In the Lake St. Clair drainage, Pugnose Shiner was captured in Mitchell's Bay in 1983, 1996, 1999 and 2006, and in St. Luke's Bay in 1983 and 2006 (DFO 2010). A 2003 targeted survey for Pugnose Shiner in the Lake St. Clair watershed found specimens in Little Bear Creek (2 specimens) and Whitebread Drain/Grape Run (3), two tributaries of Lake St. Clair. Subsequent sampling collected Pugnose Shiner in MacLeod Creek (9) in 2007, and Chenail Ecarte (23), Little Bear Creek (10) and Maxwell Creek (1) in 2010 (DFO, unpubl. data). An additional 31 sites were sampled in 2007 but Pugnose Shiner was not detected (DFO, unpubl. data). In 1999 and 2002, coastal marshes of Walpole Island were sampled with a total of 281 Pugnose Shiner caught (Royal Ontario Museum (ROM), unpubl. data). Pugnose Shiner was detected for the first time with a single specimen in the St. Clair National Wildlife Area in 2003 (Mandrak *et al.* 2006a), and again in 2004. In 2005, DFO sampled 20 sites in the St. Clair National Wildlife Area using fine-mesh fyke nets and did not collect any Pugnose Shiner (Marson *et al.* 2010). The OMNR conducted nearshore fish surveys using seines at eight sites in Lake St. Clair in 1990-1996, 2005, 2007-2011 (with an additional 9 sites in 2007 sampled by a combination of seining and boat electrofishing) (M. Belore, OMNR, pers. comm.). During this sampling, four Pugnose Shiner were caught in Lake St. Clair in 1993 (Mitchell's Bay (n=1); Pike Creek (n=3)); as there were no vouchers for these records, they were not included in Figure 6. In 2007, five Pugnose Shiner were caught during electrofishing at Mitchell's Bay. In 2010, one Pugnose Shiner was caught at Mitchell's Bay. In 2011, nine Pugnose Shiner were caught (Belle River East (n=2); Mitchell's Bay (n=6); Peter Street (n=1)).

Despite historical sampling by the ROM in the Detroit River in 1940 and 1941, Pugnose Shiner was first captured in wetlands at the mouth of the Canard River, a Detroit River tributary, in 1994 (ROM, unpubl. data). A single individual was caught trawling near Peche Island in 2011 (DFO, unpubl. data). Lapointe (2005) intensively sampled shallow water sites throughout the Detroit River, including the mouth of the Canard River, using seine nets, boat electrofishing, hoop nets, Windermere traps, trap nets, and minnow traps in 2003 (30 sites), and strictly seine nets in 2004 (60 sites) and did not collect any Pugnose Shiner. Boat electrofishing 40 sites in 2003, six sites in 2004, and 24 sites in 2011, and Missouri trawling eight sites in 2010 and 23 sites in 2011 in the Detroit River, including the mouth of the Canard River and the vicinity of Peche Island, failed to capture any Pugnose Shiner, except as noted above (DFO, unpubl. data).

In the Lake Erie drainage, Pugnose Shiner was collected in Point Pelee National Park only in two (1940, 1941) of 15 different years since 1913 in which fish surveys were conducted by the Canadian Museum of Nature (CMN), ROM, Park staff and others (Surette 2006). Since then, surveys from 1946, and more recent surveys between 1979 and 2004 have not detected Pugnose Shiner, including sampling of 320 sites in 2002 and 314 sites in 2003 using a variety of gears (hoop nets, minnow traps, Windermere traps, trap nets, bag seines, straight seines) (Surette 2006). It is believed to be extirpated from Point Pelee National Park (DFO 2010).

It was collected in Rondeau Bay in 1940 and 1963. Prior to the first report in Rondeau Bay in 1940, the bay was sampled in 14 different years since 1921 by the CMN and ROM (ROM, unpubl. data), and in 10 different years since the last reported capture in 1963 (DFO, ROM, unpubl. data). Recent sampling included boat electrofishing (>1000 sec/500m site) and fine-mesh hoopnetting (2 nets set overnight) around Rondeau Bay in 2002 (10 sites, electrofishing only) and 2004 (16 sites). No specimens were caught in 2005 and 2006 despite extensive sampling of the inner marshes of Rondeau Provincial Park by seining, fine-mesh fyke netting, and electrofishing, and outside the provincial park by fyke netting (6mm mesh) at 8 sites for two nights in 2011 (DFO, unpubl. data; T. MacDougall, OMNR (OMNR), unpubl. data). It is believed that the Rondeau Bay population is extirpated (DFO 2010).

Pugnose Shiner was first collected in Long Point Bay (Long Point National Wildlife Area and the area west of Turkey Point) in 1947 and then 1996 (Holm and Mandrak 2002). In a 2004 fish community survey, 29 Pugnose Shiner were caught at 12 sites in Long Point Bay, another one at a site in the Thoroughfare Point Unit of Long Point National Wildlife Area (Marson *et al.* 2010), and 22 individuals were caught in 2009 (DFO, unpubl. data), all by boat electrofishing. In 2011, 25 individuals were caught by targeted seining (DFO, unpubl. data). Pugnose Shiner were not captured at 47 other sites sampled by boat electrofishing, 2002-2005, and 24 sites sampled by fine-mesh fyke nets in 2005 (Marson *et al.* 2010). DFO surveys resulted in the capture of Pugnose Shiner in lower Big Creek in 2007 (7) and 2008 (1) by seining, and at Turkey Point in 2007 (22) by boat electrofishing and hoopnetting (DFO, unpubl. data). In 2007, OMNR collected 976 Pugnose Shiner at 22 of 34 sites seined one to three times over the summer, and 12 specimens at two of three sites boat electrofished in Long Point Bay (K. Oldenburg, OMNR, unpubl. data). In 2008, OMNR caught 33 Pugnose Shiner at six sites in Crown Marsh within Long Point Bay (K. Oldenburg, OMNR, unpubl. data). The Turkey Point area was seined by OMNR in 2007 (six sites; 0 specimens) and in 2009 (eight sites; 22 specimens).

The Pugnose Shiner was first collected in the Canadian portion of the Lake Ontario drainage in 2009 (DFO 2010). Two Pugnose Shiner were collected from West Lake in Prince Edward County during a boat electrofishing study in June 2009. This study has been systematically sampling the fish community in West Lake along 18 100m transects twice a year in 1998, 1999, and 2002, and at 12 points in 2002 (Brousseau *et al.* 2005). Seining targeting Pugnose Shiner in West Lake captured 32 individuals in October 2009, and 71 individuals in 2010 (DFO, unpubl. data). Seining conducted in 2010 targeting Pugnose Shiner caught individuals in the following waterbodies in and around Prince Edward County for the first time: Wellers Bay (65 individuals); East Lake (116); Black River (55); and Waupoos Bay (179) (DFO unpubl. data). Brousseau *et al.* (2005) systematically sampled the fish community in the mouth of the Black River by electrofishing along 16 100m transects twice a year in 1998, 1999, 2000, and 2001, and at six points in 2002. The fish communities at most of these locations had been sampled in the past by DFO, OMNR, and/or the ROM but not necessarily in a systematic manner nor using gears efficient for Pugnose Shiner capture (DFO, ROM, unpubl. data).

In 2011, Pugnose Shiner (58 individuals) was collected for the first time in the Trent River, a tributary to the Bay of Quinte, Lake Ontario, at Glen Ross (DFO, unpubl. data). The specimens were collected in a systematic survey of the fish community using boat electrofishing. This survey replicated sampling done using the same methods and effort in 1999, 2000, and 2001 (Watershed Science Centre 2001).

The Pugnose Shiner has been collected in the St. Lawrence River from Eastview (about 10 km east of Kingston) in the west downstream to Lancaster in the east. In Canada, it was first collected in the St. Lawrence River near the town of Gananoque and in the Gananoque River in 1935 (Toner 1937). It has not been collected in the Gananoque River since 1935 and it was last recorded from the Gananoque site on the St. Lawrence River in 1937 (Holm and Mandrak 2002); however, individuals were caught in 1989 at points east (Mallorytown Landing) and west (Eastview) of the original location (Holm and Mandrak 2002). In 2005, DFO captured 256 (39-72 mm TL) Pugnose Shiner from three sites in the vicinity of the St. Lawrence Islands National Park, near the Grenadier Island Wetland Complex including 247 specimens caught at one site on the north shore of Thompson's Bay (Mandrak *et al.* 2006b). Additionally, Parks Canada has records for 312 Pugnose Shiner collected from 16 additional sites of over 300 seined 2006-2011 throughout the Thousand Islands region from just west of Gananoque to just east of Mallorytown Landing (J. Van Wieren, pers. comm., 2011). Using boat seines, DFO captured 57 individuals at seven sites between Eastview and Mallorytown Landing in 2009, 222 individuals at 10 sites between Thompson's Bay and Mallorytown Landing in 2010, and 66 specimens at seven sites between Thompson's Bay and Lancaster, the easternmost known record, in 2011 (DFO, unpubl. data).

HABITAT

Habitat Requirements

In the United States, Pugnose Shiner is typically found in clear, heavily vegetated lakes and embayments, and slow-moving streams (Becker 1983, Carlson 1997; Page and Burr 2011). In Minnesota, Pugnose Shiner prefer sand, mud, or gravel substrates, and are commonly found in pondweed (*Potamogeton* spp.), water milfoil (*Myriophyllum* spp.), elodea (*Elodea* spp.), eelgrass (*Zostera maritima*), coontail (*Ceratophyllum* spp.), bulrush (*Scirpus* spp.), stoneworts (*Chara* spp.), and filamentous algae (Minnesota DNR 2011). The presence of rooted aquatic plants appears to be more important than the substrate type (Minnesota DNR 2011). Pugnose Shiner is extremely intolerant to siltation and turbidity (Becker 1983).

In Canada, the Pugnose Shiner is found in quiet areas of large lakes, stagnant channels, and large rivers primarily on sand and silt bottoms with organic detritus (Scott and Crossman 1973; Lane *et al.* 1996). Pugnose Shiner has also been recorded from river systems that have characteristics similar to coastal wetlands and lake systems (DFO 2010). Water is usually clear although individuals have been occasionally caught in water with a secchi reading as low as 0.3 m (e.g. Lake St. Clair, ROM 43420). This species is almost always found in association with submergent and emergent aquatic vegetation (Lane *et al.* 1996). It was captured on Walpole Island at 16 sites where it was found at a depth of up to 2.3 m over substrates containing muck, sand, marl and, occasionally, silt and clay in areas that were usually heavily vegetated with submerged aquatic plants including *Chara, Vallisneria, Heteranthera, Myriophyllum, Najas, Potamogeton,* and *Elodea* (Lane *et al.*1996; ROM unpubl. data). The following is the summary of habitat characteristics where Pugnose Shiner were caught based on 264 sampling events, 2002-2012, throughout its Canadian range (DFO, unpubl. data): conductivity (mean=317.8 µhmos; max=640 µhmos; min=126 µhmos; std=98.4; n=226); dissolved oxygen (mean=9.6 mg/l; max=15.6 mg/l; min=0.75 mg/l; std=2.4; n=121); pH (mean=8.4; n=122); secchi disc depth (mean=1.4 m; max=2.9 m; min=0.3 m; std=0.57; n=62); secchi tube depth (mean=0.6 m; max=1.2 m; min=0.28 m; std=0.30; n=57); turbidity (mean=5.6 NTU; max=120 NTU; min=0.5 NTU; std=13.6; n=77); dominant vegetation (n=225; submergent 88%; emergent 8%; floating 7%); and dominant substrate (n=230; sand 45%; silt 24%; organic 20%; clay 6%; gravel 3%; cobble 0.04%).

Habitat Trends

The current Canadian range of Pugnose Shiner is smaller than its original distribution due to its extreme sensitivity to turbidity and its requirement for clear water and heavily vegetated habitats with clean sand or marl bottoms (Scott and Crossman 1973). Loss of habitat, including the removal and control of aquatic vegetation and habitat modifications, and habitat degradation through sediment and nutrient loading has occurred throughout the range of Pugnose Shiner (DFO 2010). The destruction of preferred habitat throughout the Great Lakes has resulted in a loss of connectivity between fragmented populations, which may be inhibiting gene flow between populations (Leslie and Timmins 2002; McCusker *et al.* draft). Ongoing habitat degradation occurs in many of its former habitats (e.g. Lake St. Clair watershed); however, some areas have shown recent improvements in water clarity due to phosphorus control and Zebra Mussels (*Dreissena polymorpha*) (e.g. Bay of Quinte (Leisti *et al.* 2006).

A threats assessment was completed for Lake Erie drainage (4 sites), Lake Huron drainage (2 sites), Lake St. Clair drainage (2 sites), and Lake Ontario drainage (3 sites) (Bouvier *et al.* 2010). Overall, threats were assessed as high at the majority of the sites, associated with habitat modifications, aquatic vegetation removal, sediment loading, and nutrient loading (Table 3). Exotic species and baitfish harvesting were assessed as medium to low threats at most sites (Table 3).

Table 3. Threat Status for all Pugnose Shiner populations in Canada, resulting from an analysis of both the threat likelihood and threat impact. The number in brackets refers to the level of certainty assigned to each threat status, which is reflective of the lowest level of certainty associated with either initial parameter (threat likelihood, or threat impact). Clear cells do not necessarily represent a lack of a relationship between a population and a threat; rather, they indicate that either the threat likelihood or threat impact was unknown. From Bouvier *et al.* (2010).

	Lake Erie Drainage				Lake Huron Drainage	
Threats	Long Point Bay	Canard River	Point Pelee	Rondeau Bay	Old Ausable Channel	Teeswater River
Habitat modifications	High (3)	High (3)	Medium (3)	High (3)	High (3)	Unknown (3)
Aquatic vegetation removal	Medium (3)	Medium (3)	Medium (3)	High (3)	Medium (3)	Unknown (3)
Sediment loading	High (3)	High (3)	Medium (3)	High (3)	High (3)	Unknown (3)
Nutrient loading	High (3)	High (3)	Medium (3)	High (3)	High (3)	Unknown (3)
Exotic species	Medium (3)	Medium (3)	Medium (3)	Medium (3)	Medium (3)	Unknown (3)
Baitfish industry	Low (3)	Low (3)	Low (3)	Low (3)	Low (3)	Low (3)
Changes in trophic dynamics	Unknown (3)	Unknown (3)	Low (3)	Low (3)	Low (3)	Unknown (3)

	Lake St. Clair Drainage		Lake Ontario Drainage		
Threats	Lake St. Clair	St. Clair NWA	St. Lawrence River	Gananoque River	West Lake
Habitat modifications	High (3)	High (3)	Medium (3)	Unknown (3)	Medium (3)
Aquatic vegetation removal	Medium (3)	Medium (3)	Medium (3)	Unknown (3)	Medium (3)
Sediment loading	High (3)	Medium (3)	High (3)	Unknown (3)	High (3)
Nutrient loading	High (3)	Medium (3)	High (3)	Unknown (3)	High (3)
Exotic species	Medium (3)	Medium (3)	Medium (3)	Unknown (3)	Medium (3)
Baitfish industry	Low (3)	Low (3)	Low (3)	Low (3)	Low (3)
Changes in trophic dynamics	Unknown (3)	Unknown (3)	Unknown (3)	Unknown (3)	Unknown (3)

Venturelli *et al.* (2010) calculated the minimum area for population viability (MAPV) for Pugnose Shiner. MAPV is a quantification of the amount of habitat required to support a viable population. Variables included in the MAPV assessment include previously calculated minimum viable population (MVP) values, and area required per adult individual (API values). API values were estimated from an allometry for lake and river environments. With a target MVP of 1 929 adults under a 0.05 probability of catastrophe per generation, the MAPV in lakes is 0.7 ha and 0.2 ha in rivers. With a target MVP of 14 325 under a 0.10 probability of catastrophe per generation, the MAPV in lakes is 5 ha and 1.5 ha in rivers. Although the total area of each site is not known, at least eight sites (Little Bear Creek, Macleod Creek, Maxwell Creek, Mouth Lake, Old Ausable Channel, Teeswater Creek, Trent River, Whitebread Drain/Grape Run) are likely under these thresholds. Based on this and the lack of connectivity identified above, the distribution of the Pugnose Shiner in Canada should be considered severely fragmented.

BIOLOGY

Life Cycle and Reproduction

There is much uncertainty surrounding the life history of Pugnose Shiner. Its small size, elusive nature, and preference for areas with dense macrophyte coverage make it difficult to sample (DFO 2010). It is a lithophil – a nonguarding, open substrate spawner (Leslie and Timmins 2002). Pugnose Shiner is known to spawn in densely vegetated, shallow water (2 m maximum depth), with a sand, silt and gravel substrate (Leslie and Timmins 2002). Submergent aquatic vegetation appears to play an important role in the spawning process.

In Wisconsin, spawning was not observed but, based on appearance of gravid females, it likely occurred from mid-May into July at temperatures of 21-29°C. Gravid females had 530-1275 eggs but some of these may not have been laid. Average sizes (total length in mm) at age on 8 August in a Wisconsin population were: age I (38-44, mean=42.0), age II (45-49, mean=46.3) and age III (52-53, mean=52.5) (Becker 1983). Maximum age is three (Becker 1983).

In Ontario, Pugnose Shiners caught on 7 June 1996 in Mitchell Bay, Lake St. Clair were likely in the midst of spawning as some females appeared to be partially spent. Mature females were 41-56 mm TL (n=10) and mature males were 30-38 mm TL (n=10) (ROM, unpubl. data). Based on average sizes provided in Becker (1983), Pugnose Shiner likely mature in the second year of life (i.e. Age I). Leslie and Timmins (2002) found mean total length in age 0 fishes to be 24.1 mm. The Ontario and global record for Pugnose Shiner is 72 mm TL (ROM 79046).

Given a maximum age of three (Becker 1983) and an age of maturity of one, the generation time would be two years.

Physiology and Adaptability

The Pugnose Shiner has strict habitat requirements of aquatic vegetation, which provides cover, food, and breeding sites (Becker 1983, Smith 1985). Based on aquarium studies, this species is timid and secretive and would, therefore, be less susceptible to entrapment gear (Becker 1983). Its habit of staying near cover and going into hiding at any motion or disturbance would presumably also reduce its susceptibility to predation. Although it has a very small mouth, it can consume food items up to 2 mm long and twice the length of the mouth (Becker 1983).

The Pugnose Shiner is thought to be intolerant of high turbidity (Becker 1983). Gray *et al.* (draft) used a progressive acclimation experiment to test if Pugnose Shiner behaviour is altered by increasing turbidity, in comparison to three more common congeners, and quantified Pugnose Shiner swim performance in clear- and turbid-acclimated fish. Pugnose Shiner schooling behaviour was altered starting at very low turbidity (~2.0 NTU; nephelometric turbidity units), whereas, behaviour did not vary across turbidity levels in three more common congeners (Figure 7). Critical swim speed was lower in Pugnose Shiner acclimated to turbid *vs.* clear water (Figure 8). These results demonstrate that very low levels of turbidity (<10 NTU) can disrupt schooling behaviour and decrease swim performance in Pugnose Shiner.

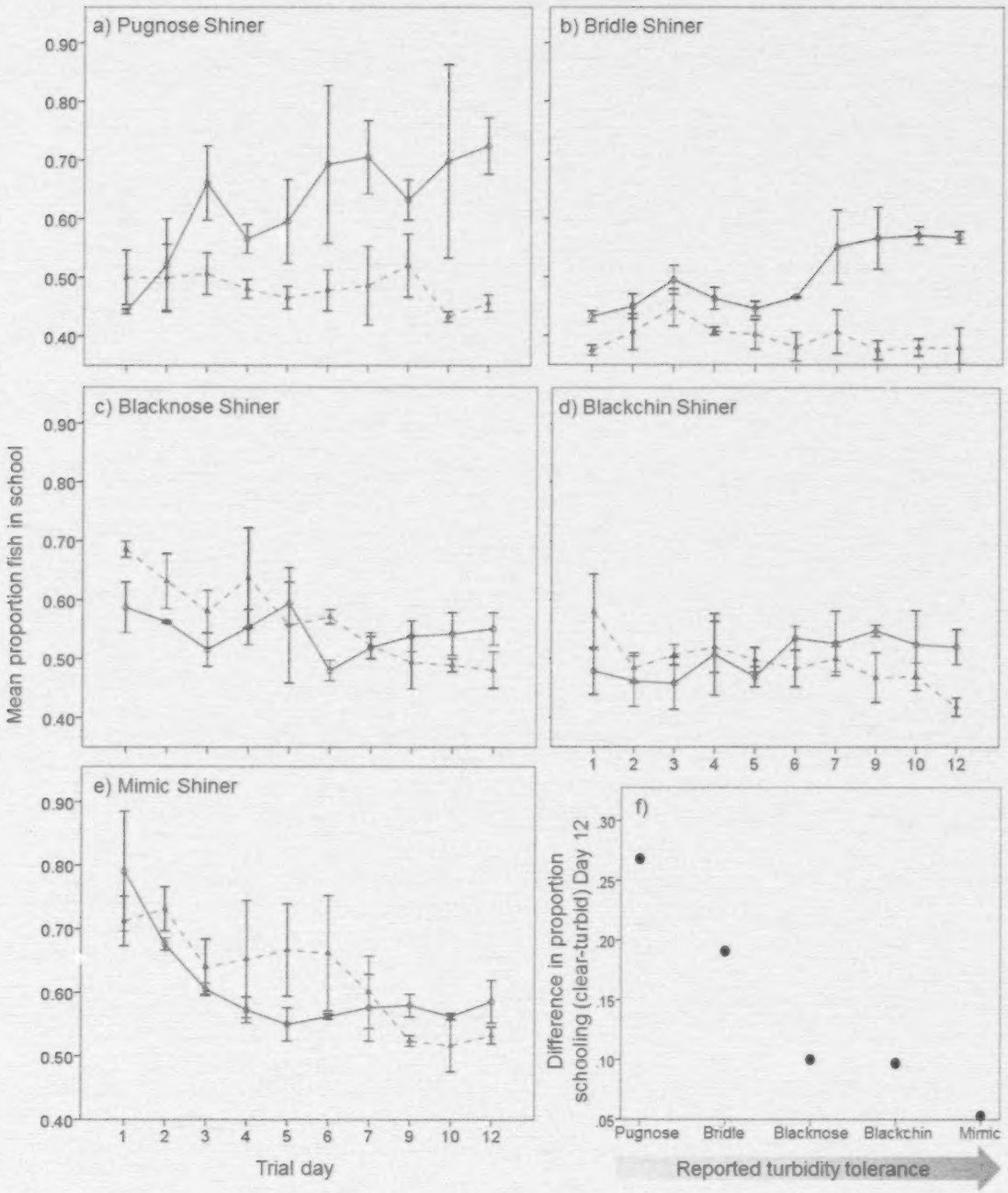

Figure 7. Mean proportion (± s.e.) of fish in a school calculated for each treatment (clear: open circles, solid line; turbid: open triangles, dashed line) every day of the progressive acclimation trial for a) Pugnose Shiner, b) Bridle Shiner, c) Blacknose Shiner, d) Blackchin Shiner, and e) Mimic Shiner. Turbidity was increased in turbid treatment aquaria daily. Days 8 and 11 had unexpectedly high turbidity values in some aquaria and so were removed from the experiment. f) The difference in mean proportion of fish schooling between clear and turbid treatments on the last day of the trials, with species listed in order of turbidity tolerance from intolerant to moderately tolerant. Gray *et al.* (draft).

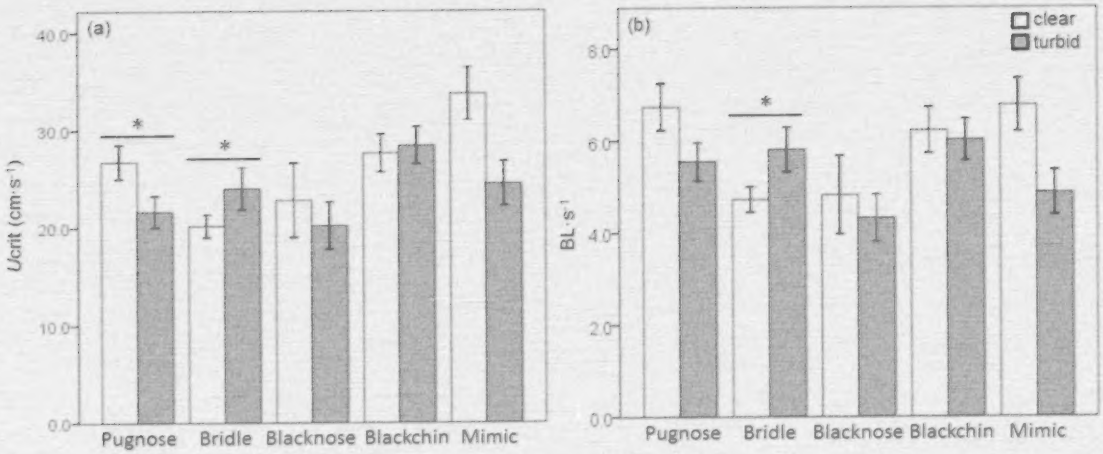

Figure 8. Mean (± s.e.) swim performance for five *Notropis* spp. acclimated for more than one month to clear (white bars) and turbid (grey bars) water, as given by (a) critical swimming speed (U_{crit}) and (b) body lengths per second ($BL \cdot s^{-1}$). Significant pair-wise differences between treatments are indicated by a bar and asterisk.

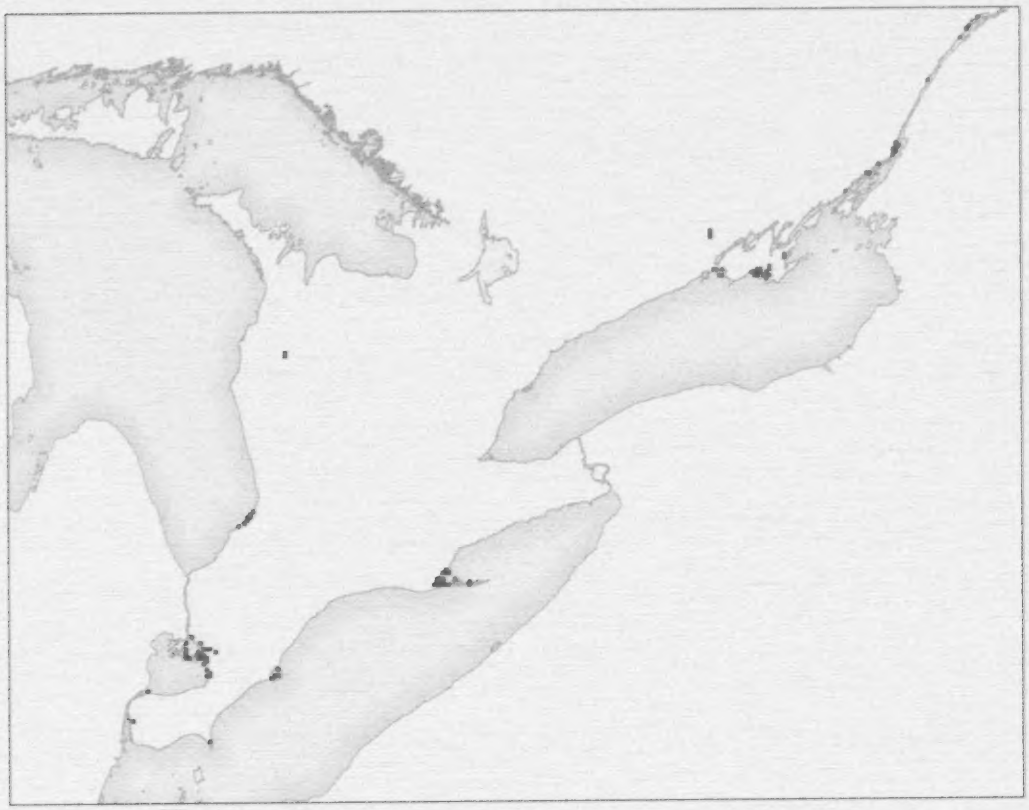

Figure 9. 2 km x 2km grids used to estimate area of occupancy.

Dispersal and Migration

There have been no published studies on migration or size of home range in the Pugnose Shiner. It is likely that its small size and weak swimming ability limit its movement to small distances. During summer months, this species can be found in shallow waters, and during the winter it moves to deeper waters (Lee *et al.* 1980; Trautman 1981; Becker 1983; Smith 1985; Minnesota DNR 2011).

Food and Feeding

The Pugnose Shiner is both a detritivore and omnivore. In Wisconsin, plants such as *Chara* and filamentous green algae (e.g. *Spirogyra*) were preferred over animal prey such as the cladocerans, *Daphnia* and *Chydorus* (Becker 1983). Small leeches and trichopterans have also been observed in its diet (Carlson 1997). Eight specimens from Mitchell's Bay, Lake St. Clair, captured in June contained primarily small cladocerans (0.25-0.38 mm) of *Chydorus sphaericus* and *Bosmina longirostris*, two widespread and common species. One female individual of 43 mm TL contained an estimated 1210 *C. sphaericus* and 370 *B. longirostris* (ROM, unpubl. data).

Interspecific Interactions

There is a strong relationship between the presence of Blackchin Shiner and Pugnose Shiner in the Thousand Islands, New York (Carlson 1997). When Blackchin Shiner was collected, there was a high probability of also catching Pugnose Shiner, showing that the more common Blackchin Shiner is a good indicator of the presence of the rare Pugnose Shiner. Pugnose Shiner is also associated with Blacknose Shiner although this species has a far greater range than the Pugnose Shiner (NatureServe 2011). Other species commonly associated with the Pugnose Shiner include Tessellated Darter (*Etheostoma olmstedi*), Bluntnose Minnow (*Pimephales notatus*), Banded Killifish (*Fundulus diaphanus*), and Bluegill (*Lepomis macrochirus*) (Carlson 1997).

The extirpation of Pugnose Shiner and seven other fish species in one lake in Wisconsin was associated with the introduction and spread of Eurasian Water Milfoil, *Myriophyllum spicatum* (Lyons 1989). Most of the Canadian habitat of the Pugnose Shiner has been affected by the introduced Zebra Mussel and Quagga Mussel (*D. bugensis*). Their effect on the Pugnose Shiner is unknown, but it is possible that the increased water clarity and macrophytes proliferation associated with these invasive species may benefit this species.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

See **Search Effort** subsection within the "Distribution" section for details on sampling effort and methods by population.

Abundance

Population sizes of Pugnose Shiner are not known for populations in Canada. In 2010, DFO and OMNR attempted to estimate population sizes using depletion sampling of eight Pugnose Shiner populations in Canada. Data were sufficient to estimate the mean density of individuals in suitable habitat in four populations; it ranged from 0.051 individuals/m^2 in the St. Lawrence River to 0.156 individuals/m^2 in East Lake (S. Reid, OMNR, unpubl. data). Additional study is required to measure the total amount of suitable habitat in order to determine population size.

Fluctuations and Trends

The lack of historical sampling at many locations with recent records makes it difficult to evaluate trends in distribution. The Pugnose Shiner has been confused with other blackline shiners with which it commonly co-occurs (Holm *et al.* 2010), and errors in species identification have undoubtedly been made, likely resulting in inaccurate estimates of distribution and abundance.

Although population trends cannot be specifically examined in Ontario, repeated sampling at some known Pugnose Shiner sites has occurred. Repeated collecting at Point Pelee, Rondeau Bay, and the Gananoque River indicate that these populations are now extirpated. In the Recovery Potential Assessment for this species, which considers trends, the status of the Long Point Bay population was ranked as poor, the Old Ausable Channel and Lake St. Clair populations as fair, and the St. Lawrence population as good (DFO 2010). The status of the Canard River, Detroit River, East Lake, Mouth Lake, St. Clair National Wildlife Area, Teeswater River, Waupoos Bay, Wellers Bay, and West Lake populations was ranked as unknown due to lack of data (DFO 2010; Edwards *et al.* 2012).

Rescue Effect

The Pugnose Shiner is found on the American side of the St. Lawrence River adjacent to the Canadian populations; however, the species is considered critically imperilled (S1) in New York. Rescue effect across the St. Lawrence is likely limited by the rarity of the species in New York, and the linear flow of the St. Lawrence River and lack of suitable habitat mid-stream as a barrier to cross-flow movement of this small, weak swimmer. The species is considered vulnerable (S3) in Michigan, but the populations nearest to Canadian populations are found in Lake St. Clair headwaters (Bailey *et al.* 2004); therefore, rescue effect across Lake St. Clair and its tributaries would be limited by unsuitable habitat. The Ohio population is extirpated; therefore, rescue effect in Lake Erie is not possible.

THREATS AND LIMITING FACTORS

Degradation and loss of preferred habitat, including removal and control of aquatic vegetation, habitat modification, and sediment and nutrient loading, are the greatest threats to the Pugnose Shiner (Table 3; Bailey 1959, Trautman 1981, Herkert 1992, DFO 2010). Loss of habitat from shore development and destruction of native littoral-zone macrophyte communities probably caused the extirpation of the Pugnose Shiner from two lakes in southern Wisconsin (J. Lyons, WDNR, personal communication). In experimental studies, turbidity has been shown to significantly negatively affect schooling behaviour and swimming performance (Gray *et al.* draft). Exotic species (fishes and aquatic macrophytes) and incidental harvest from the baitfish industry may also negatively impact the Pugnose Shiner (DFO 2010). The introduction of whole-lake treatment with herbicides in the United States has also been considered a threat (NatureServe 2010). Climate change may have direct and indirect effects because of the specific habitat vulnerabilities of this species (DFO 2010). Chu *et al.* (2005) suggested that climate change would allow the potential expansion of Pugnose Shiner in Canada; however, such expansion would be limited by watershed divides unless movement was facilitated by humans. In an assessment of vulnerabilities of coastal wetland fishes to climate change, Doka *et al.* (2006) assessed the Pugnose Shiner as highly vulnerable (ranked sixth most vulnerable of 99 species) as a result of the loss of wetlands due to climate change.

Although degradation and loss of aquatic habitat is contributing to its decline in Canada, evidence from Point Pelee suggests that other factors may be involved. Parks on Point Pelee and Rondeau Bay that would presumably offer protection from habitat changes have failed to prevent its decline or extirpation. Although Point Pelee experiences periodic turbidity in rough weather, water is generally clear with an abundance of a variety of aquatic plants. In these areas, a factor that may have contributed to the decline of the Pugnose Shiner is an increase in the number and diversity of predators. There is evidence that minnow diversity and abundance decreases with an increase in numbers and diversity of littoral predators such as basses (*Micropterus* spp.) and pikes (*Esox* spp.) (Whittier *et al.* 1997). Although the Northern Pike (*Esox lucius*) and Grass Pickerel (*E. americanus vermiculatus*) were known to occur at Point Pelee in the 1940s, potential predators such as Largemouth Bass (*Micropterus salmoides*), Warmouth (*Lepomis gulosus*), and Black Crappie (*Pomoxis nigromaculatus*) were not recorded prior to 1958. However, the Pugnose Shiner was found in association with a wide variety of potential predators in 1999 at Walpole Island where it is relatively common (ROM unpubl. data). These were frequently abundant and included Bowfin (*Amia calva*), Longnose Gar (*Lepisosteus osseus*), Northern Pike, Grass Pickerel, bullheads (*Ameiurus* spp), Rock Bass (*Ambloplites rupestris*), Largemouth Bass, Black Crappie and Yellow Perch (*Perca flavescens*).

Another factor that may play a role in the decline or extirpation of the Pugnose Shiner at Point Pelee is competition for resources with species such as Bluegill (*Lepomis macrochirus*), juvenile Black Crappie, and Brook Silverside (*Labidesthes sicculus*). These species feed heavily on cladocerans and to some extent on plant material and did not occur in collections previous to 1958 (Surette 2006).

Changes in the aquatic plant community on which the species depends could also be a limiting factor. The extirpation of the Pugnose Shiner and seven other fish species in one lake in Wisconsin was associated with the introduction and explosive increase of Eurasian Water Milfoil (Lyons 1989). Eurasian Water Milfoil occurs at Point Pelee, but it is not known with certainty when this species became established; a record from 1961 has not been verified. In the St. Clair - Detroit River system it was first recorded in 1974 and by 1978 was the fourth most common submerged macrophyte (Schloesser and Manny 1984).

PROTECTION, STATUS, AND RANKS

Legal Protection and Status

The Pugnose Shiner is listed as Endangered under the federal *Species at Risk Act* (SARA) and has been protected under the SARA as of June 2003. The Pugnose Shiner is listed as Endangered by the Ontario *Endangered Species Act*, 2007, which affords some protection to Pugnose Shiner and its habitat. As required by SARA, a draft recovery strategy has been prepared for the Pugnose Shiner (Edwards *et al.* 2012).

Non-Legal Status and Ranks

The Pugnose Shiner is listed as vulnerable globally (G3) and nationally in the United States (N3). In Canada, it is ranked as imperilled (N2). It is considered vulnerable (S3) in Michigan and Minnesota; imperilled (S2) in Wisconsin; critically imperilled (S1) in Illinois, Indiana, Iowa, New York, and North Dakota; and extirpated (SX) in Ohio. In Ontario, it is ranked imperilled (S2) (NatureServe 2011). The species is listed as Threatened globally by the American Fisheries Society (Jelks *et al.* 2008).

Habitat Protection and Ownership

The federal *Fisheries Act* historically represented the single most important piece of legislation protecting the Pugnose Shiner and its habitat in Canada. However, recent changes to the *Fisheries Act* have significantly altered protection for this species and it is unclear at this time if the *Fisheries Act* will continue to provide any protection for this species.

Habitats within Big Creek National Wildlife Area (NWA), Long Point Bay NWA, Point Pelee National Park, Sandbanks Provincial Park, St. Clair NWA, St. Lawrence Islands National Park, and Wellers Bay NWA and is afforded protection under the *Canada National Parks Act* administered by Parks Canada. Ontario legislation that may protect habitat of Pugnose Shiner includes the *Environmental Protection Act*, *Ontario Environmental Assessment Act*, *Game and Fish Act*, *Planning Act*, and *Water Resources Act*. In Ontario, aquatic habitats that fall within regulated lands of a Conservation Authority are protected against wetland infilling, shoreline alterations, and work occurring within the floodplain by the *Conservations Authorities Act*. The federal *Species at Risk Act* and Ontario *Endangered Species Act*, 2007 afford protection to both species and habitat.

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

The following authorities were contacted and a response received: Canadian Museum of Nature; OMNR Natural Heritage Information Centre; OMNR Glenora; OMNR Kemptville; OMNR Peterborough; Parks Canada; Quinte Conservation Authority; Raisin River Conservation Authority; Rideau Valley Conservation Authority; and Trent Valley Conservation Authority.

The following authorities were contacted and a response was not received: Cataraqui Region Conservation Authority; Lower Trent Valley Conservation Authority; South Nation Conservation Authority.

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COLLECTIONS EXAMINED

None.